REMARKS

Claims 2, 6-11, and 26-34 are pending. A complete listing of the claims is provided for the Examiner's convenience.

I. 37 CFR 1.116.

Applicants are respectfully aware of the limitations after final rejection according to 37 CFR 1.116 and have respectfully endeavored to summarily point out the USPTO's errors and place the application in condition for allowance.

II. The obviousness rejection of independent claim 2, 5, 6, 8-11, 26-28 and 30-34.

In the Office Action, the USPTO rejects independent claim 2 under 35 USC 103(a) as being obvious over Wilkins (6212254), and in response to Applicant's arguments, the USPTO asserts as follows:

"While Wilkins observes that a .1 mm source would yield less than optimum images in the examples shown in figures 4 and 5 (because the boundary being imaged is only 10μ), he nonetheless explains that a source of 100 μ(.1mm) may be employed, and contrary to applicant's belief that Wilkins teaches away from the claimed limitation, it is well settled that a reference must be considered for all that it teaches including non preferred embodiments. See for example in re Meinhardt, --, in re Azorlosa, --, In re Mills & Palmer, --. Thus applicant's position that Wilkins teaches away from the claimed invention is specious."

In the above assertion, there are two major issues to be argued. That is, the first issue relates to "the 100 μ source", and the second issue relates to "teaching away".

First Issue

The USPTO asserts that although a 100 μ source would yield less than optimum images, the 100 μ mm source may be employed.

However, the applicants respectfully assert that the issue is not whether or not the 100 μ source may be employed.

Namely, as the Examiner admitted, Wilkins observes that a 100 μ source would yield less than optimum images.

To compensate the lowered sharpness, the present invention increases the sharpness of the image by the sharpness enhancing step as recited in claim 2.

Therefore, it is respectfully asserted that the issue is whether or not the effect of the sharpness enhancement attained by the present invention for an image yielded by the use of the 100 μ source as one source example would have been obvious from the teaching of Wilkins.

With regard to the size of X-ray source for mammography, Wolbarst which was cited by the Examiner in the Office Action dated 07/11/2003, teaches on page 221 right column lines 13-17 (see Reference 1) to use the size of 400 μm (0.4 mm) for normal mammography and the size of 100 μm (0.1 mm) for magnification mammography in order to obtain clear visualization of microcalcification 100 to 200 μm. However, Wolbarst further teaches on page 197 Figure 22-11 (see Reference 2) that unsharpness resulting from penumbra increases with focal spot size and with magnification.

That is, although Wolbarst suggests to use the size of 100 μm for magnification mammography, Wolbarst dose not teach nor suggest a technique to solve the problem of unsharpness resulting from penumbra.

With regard to this problem of unsharpness resulting from penumbra, Wilkins also teaches that a normal fine focus source of diameter 100 μm would have a projected size of approximately the length of the 0.1 mm scale bar shown on photographs and so largely smear out contrast, see column 8 lines 44-48 and Fig. 5. In place of the 100 μm source, Wilkins teaches to use a small size source less than 20 μm to give observable contrast, see column 9 lines 10-11.

Therefore, as well as Wolbarst, although Wilkins teaches the problem of unsharpness resulting from penumbra by the use of the 100 μm source, Wilkins does not teach nor suggest the technique to solve the problem by the use of the 100 μm source. Further, the important thing is that Wilkins teaches nothing about the applicability of a 20 μm source to mammography.

In the present invention, as recited in claim 2, an X-ray image radiographing method of radiographing an object of a breast (or mammography) comprises a sharpness enhancing step of increasing a sharpness of an image lowered due to penumbra by enhancing an edge of the image with refraction contrast enhancement, the sharpness enhancement step comprising steps of:

using an X-ray tube having a size D of focal spot defined by the following formula:

$100\ \mu m \leq D \leq 600\ \mu m$;

setting a distance R1 between the X-ray tube and an object of a breast so as to be within a range defined by the following formula:

$(D-7)/200\ m \leq R1 \leq 5\ m$; and

setting a distance R2 between the object and an X-ray detector so as to be within a range defined by the following formula:

$0.15\ m \leq R2 \leq 1.4\ m$.

By the above steps, the present invention can solve the problem in the use of the 100 μm source as demonstrated in the Declaration by Mr. Honda which was submitted with AMENDMENT dated on November 7, 2003.

In other words, the present invention makes it possible to use a X-ray tube having a size D of focal spot of 100 μm to 600 μm for mammography by increasing the sharpness.

Accordingly, this achievement of the present invention would not have been obvious over Wilkins.

Further, since Wilkins does not teach nor suggest a technique to solve the problem in the use of the 100 μm source, the unexpected result demonstrated in the Declaration would not have been obvious over Wilkins.

Second Issue

As argued above, Wilkins teaches a normal fine focus source of diameter 100 μm would have a projected size of approximately the length of the 0.1 mm scale bar and so largely smear out this contrast, and Wilkins teaches to use a small size source less than 20 μm to give observable contrast in place of the 100 μm source.

Accordingly, Wilkins teaches that unless the small size source less than 20 μm is used, observable contrast may not be obtained. In other words, in order to avoid smearing out contrast, Wilkins teaches not to use the 100 μm source. Namely, Wilkins teaches away from using the 100 μm source.

Since the present invention can solve the problem of unsharpness resulting from penumbra in the use of an X-ray tube having a size D of focal spot of 100 μm to 600 μm, Wilkins teaches away the present invention to use the focal spot of 100 μm to 600 μm.

Therefore, the present invention to solve the problem of unsharpness resulting from penumbra in the use of an X-ray tube having a size D of focal spot of 100 μm to 600 μm would not have been obvious over Wilkins.

Furthermore, the Examiner asserts that Wilkins teaches a method of using an x-ray tube having a focal spot of 100 microns, setting the source-to-object distance at 700 mm, and setting the detector-to-object distance at 700 mm.

However, Wilkins merely teaches examples of using a nominal 10 μm diameter microfocus source, see column 8 lines 31-39, and Wilkins explicitly teaches that a normal fine focus source of diameter 100 μm would largely smear out contrast obtainable by the use of the 10 μm source.

Therefore, when an ordinarily skilled person considers to avoid smearing out contrast, since Wilkins teaches away to use 100 μm source, an ordinarily skilled person would not have considered to use 100 μm source in place of the 10 μm source in the examples of Wilkins.

Accordingly, the present invention would not have been obvious over Wilkins.

Thus, it is respectfully asserted that the above Examiner's assertion to use a 100 μm source in place of the 10 μm source in the examples of Wilkins is an impermissible hindsight based on the disclosure of the present invention.

On considering First Issue and Second Issue, thus, it is respectfully asserted that the present invention would have been absolutely unobvious over Wilkins.

III. Conclusion

It is believed that the foregoing amendments and remarks fully comply with the Office Action and that the claims herein should now be allowable to Applicants. Accordingly, reconsideration and allowance are requested.

If there are any additional charges with respect to this Amendment or otherwise, please charge them to Deposit Account No. 06-1130.

Respectfully submitted,

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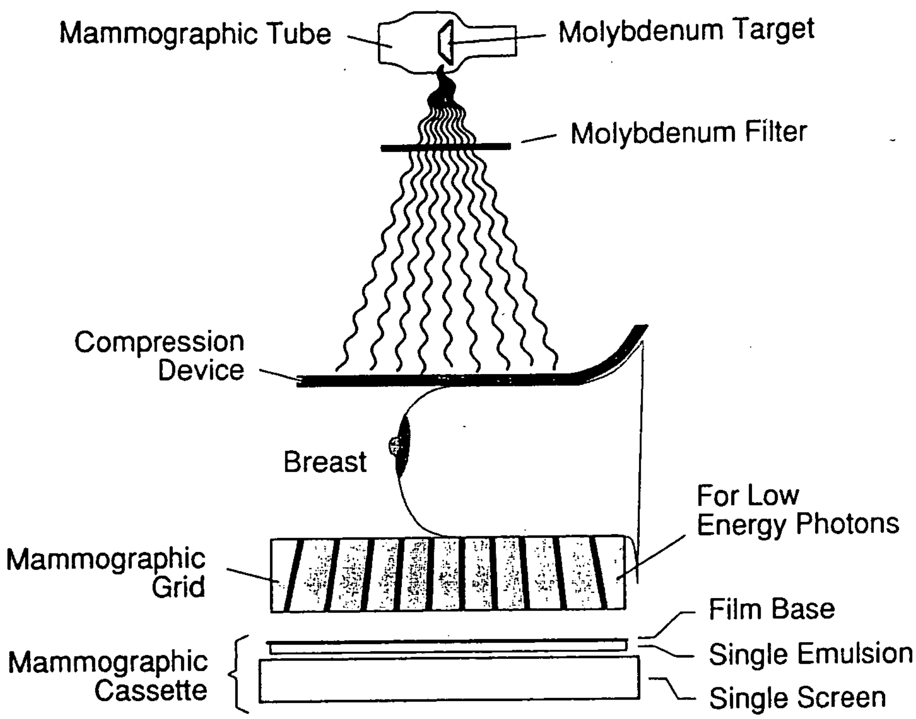

Figure 25–2. A dedicated mammographic system differs from a standard radiographic unit in that it employs an x-ray tube with a molybdenum target and a molybdenum filter; a compression device; a low-photon-energy grid; and a single-screen detail cassette containing single-emulsion film.

should have a half-value layer thickness (HVL) in aluminum of 0.3 to 0.37 mm.

A breast should always be compressed, when possible, both to increase image contrast and to reduce tissue dose. It is becoming routine practice to use a grid for most patients, especially when a breast is difficult to compress and/or contains very dense glandular tissue. Only a special mammographic grid (designed for very low energy x-rays) should be employed.

In the past, mammography was sometimes performed with film and no screen, but modern detail rare earth and calcium tungstate mammographic screens provide adequate resolution at a small fraction of the dose. A mammographic cassette, which contains only a single fluorescent screen for better resolution, should be used. Because of the low x-ray energy, a single thin screen can absorb more than 50% of the photons that reach it. The cassette is oriented so that the x-rays pass through the film before entering the screen. That way, light is emitted predominantly from the layer of screen closest to the film, where the x-rays first strike, so that light diffusion and the resultant loss of resolution are lower. The film has emulsion only on the side adjacent to the screen, to reduce crossover. In some mammographic cassettes, film and screen are drawn into close physical contact by means of a vacuum.

Reference 1

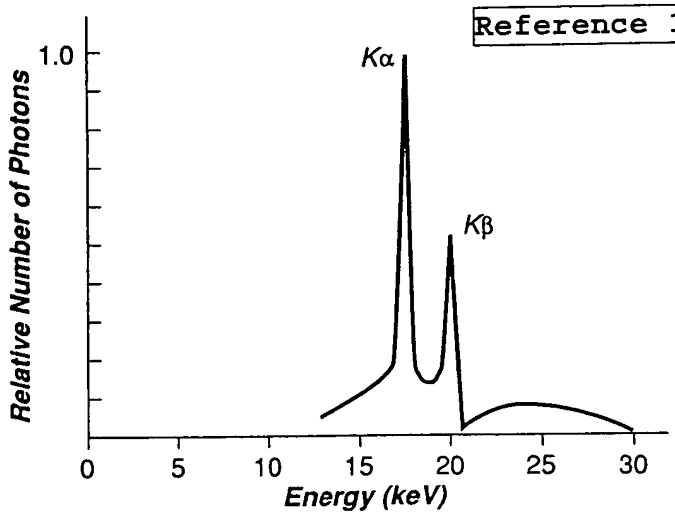

Figure 25–3. The emission spectrum for a molybdenum-target x-ray tube (plus molybdenum beamfilter) is dominated by the molybdenum characteristic x-ray peaks at 17.4 and 19.8 keV. Such a tube is normally operated between 26 and 32 kVp.

Clear visualization of microcalcifications 100 to 200 μm in dimension requires an overall system resolution of 15 lp/mm. The inherent resolution limitation imposed by the screen is a bit less than 20 lp/mm. Working through the geometry outlined in Chapter 22, Sections 5 through 8, suggests that a 0.4-mm effective focal spot is needed. If magnification radiography is to be used (or if the film is to be inspected with a magnifying glass), for a more detailed examination of microcalcifications or certain other masses, then an even smaller focal spot is required. Some mammographic tubes are designed to produce two focal spots, one 0.4 mm or so in dimension for normal mammography (with a grid), and the other about 0.1 mm across for magnification (with no grid) by a factor of 1.5 or 2. Magnification mammography should not be used for screening.

Higher speed and greater contrast can be achieved for some films with "push processing," or the extended processing cycle. Film that has been left in the developer for up to 4 minutes, and is therefore overdeveloped, results in greater average optical density (OD) and enhanced contrast. To obtain the same optimal average optical density (about OD = 1.2) as would result with normal development, a lower exposure is used, with correspondingly less dose to the breast. This re-

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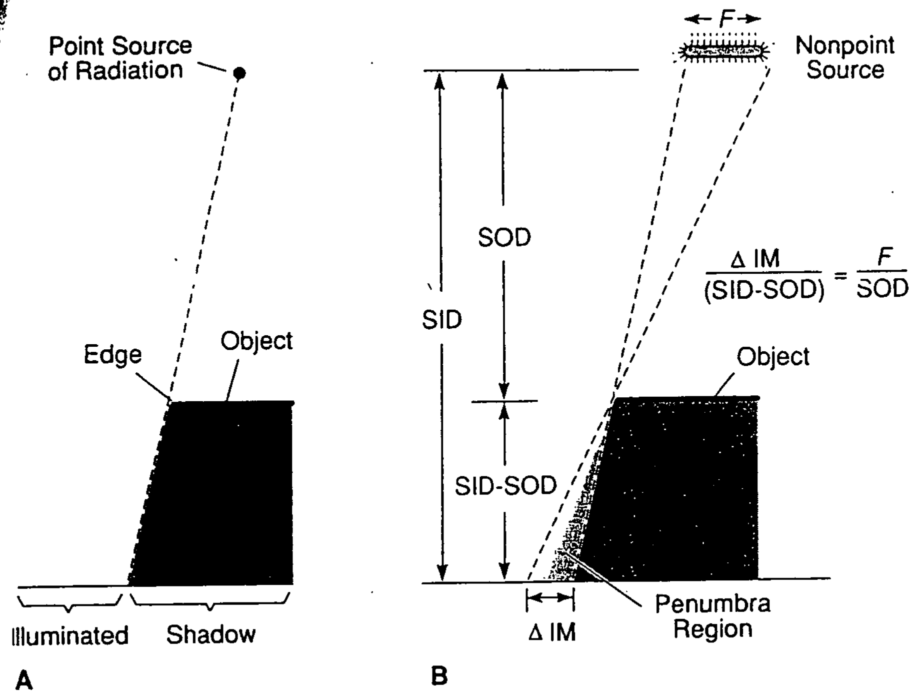

Figure 22–9. Geometric (penumbra) unsharpness. **A.** A point source of radiation will cast a sharp shadow of a sharp-edged object. **B.** There appears a region of blur, or penumbra, at the edge of the shadow image produced with a nonpoint source. The width of the penumbra region, DIM, is proportional to the dimension of the source, F. It also depends on the distances of the object from the source, SOD, and from the image plane, SID–SOD.

The last step followed from Equation 22.1. The amount of geometric unsharpness thus increases with the size of the focal spot and with the amount of magnification (Fig. 22–10). Note that when the object being imaged is against the image receptor, so that M = 1, there is no geometric unsharpness.

The relative unsharpness caused by penumbra, $U_{pen} = \Delta IM/IM$, for a 1-mm object depends on M as

$$U_{pen} = [F/(1\ \text{mm})](1 - 1/M) \qquad (22.3b)$$

Unlike the case of motional blurring, U_{pen} becomes larger with greater amounts of magnification; that is, as an image is magnified, the penumbra increases even faster. If penumbra is the dominant source of unsharpness, then one produces the best pictures by using the least amount of magnification. U_{pen} curves appear in Figure 22–11 as functions of magnification for a 1.0-mm focal spot, and for a 0.1-mm focal spot employed in magnification mammography.

Nearly all x-ray tubes used in general radiography contain two filaments, which give rise to focal spots typically 0.6 and 1.0 mm in dimension. If an adequate exposure can be obtained with a low mA, the smaller filament may be employed. If a thick part of the body is being imaged, however, or if a pulse of very short duration is required, so that a higher current is needed, the heat must be spread out over a larger focal spot on the target surface, as produced by means of the larger filament, with the associated loss of resolution. Higher tube currents

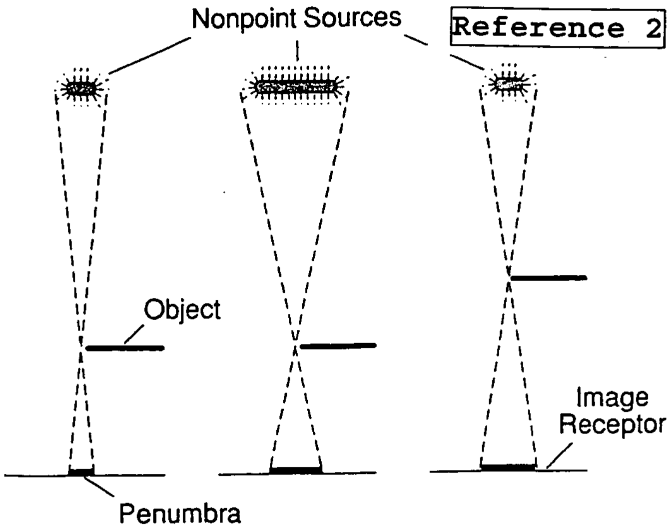

Figure 22–10. The amount of penumbra increases with the size of the source of radiation, and also for an object closer to the source.

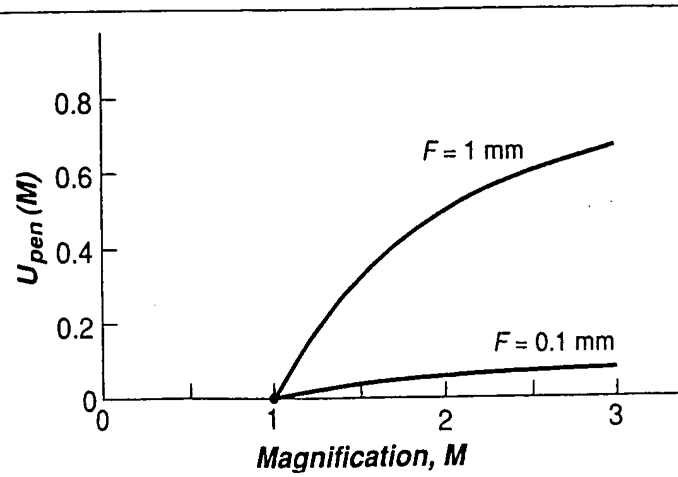

Figure 22–11. The relative geometric unsharpness resulting from penumbra, U_{pen}, increases with focal spot size and with magnification. This component of total relative unsharpness can therefore be kept down by using a small focal spot and little magnification.

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